Technological Forecasting & Social Change 106 (2016) 31–36

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Changing attitudes towards e-mobility by actively elaborating fast-charging technology

Fabian Gebauer [a,b,c], Roman Vilimek [d], Andreas Keinath [d], &, Claus-Christian Carbon [a,b,c,*]

[a] Department of General Psychology and Methodology, University of Bamberg, Bamberg, Germany
[b] Bamberg Graduate School of Affective and Cognitive Sciences (BaGrACS), Bamberg, Germany
[c] Forschungsgruppe EPÆG (Ergonomie, Psychologische Æsthetik, Gestaltung), Germany
[d] BMW Group, Concept Quality, Munich, Germany

ARTICLE INFO

Article history:
Received 9 June 2014
Received in revised form 3 February 2016
Accepted 7 February 2016
Available online xxxx

Keywords:
E-mobility
Future concept
Acceptance
Fast DC charging
Prediction

ABSTRACT

Since electromobility (e-mobility) is a large field of innovation, it is crucial to examine new developments with potential users in mind. Therefore, we investigated the impact that new fast-charging technologies for electric vehicles (EV) have on ordinary people's assessment about the future prospects of e-mobility—which is an important prerequisite for increased attitudes towards e-mobility in general. First we let participants perform a typical charging process, where they were either introduced to the slower-operating, alternating current (AC) system or the fast-operating direct current (DC) system. In a second experiment we used the same procedure but instead of letting participants actively perform the charging process, they were only given written information about these charging technologies. Results show that participants' future estimation about EVs only rises when they actively charge an EV in the fast DC condition but not in the AC condition. General attitudes towards EVs increase independently of the AC or DC condition. None of these effects could be seen without active hands-on experience (second experiment). These indications imply the value of investing in fast-charging systems to induce more favorable judgments regarding the future prospect of EVs. The importance of letting people actively take part in the way e-mobility works will be discussed regarding the potentially improvement of participants' attitudes towards e-mobility.

1. Introduction and theoretical background

Germany's transportation sector was set to be revolutionized recently, according to the German chancellor Angela Merkel, by having one million electric vehicles (EVs) on Germany's roads by 2020. Given that the number of electric cars is only 18,948 in Germany as of January 1st, 2015 (Kraftfahrt-Bundesamt, 2015), it is obviously an ambitious aim of the German government; but considering the potential of these vehicles to reduce carbon dioxide emissions, they do present a promising ecological-sustainable transportation system solution (Holdway et al., 2010). A major reason for this low number of EVs is commonly seen in the hitherto low number of EV models on sale. Considering the prognosis in the market development roadmap proposed by experts from the German National Platform for Electromobility, the strongly-increasing number of EV sales required is expected to occur during the market ramp-up phase of 2014–2017 with 15 new EV models becoming available at the beginning of the phase through German automobile manufactures alone (Nationale Plattform Elektromobilität (NPE), 2012). EVs only have a chance of succeeding in the mass market if they meet customer expectations (Vilimek and Keinath, 2014); however a recent poll has revealed that public opinion on electromobility is still quite skeptical in Germany (e-mobility; Schwedes et al., 2013; Steinhilber et al., 2013). Most of the reservations about e-mobility were caused by the limited range of EVs (Franke et al., 2012b), high costs and (infrastructural) charging complications (Bayram et al., 2013; Jin et al., 2013; Kampker et al., 2012). All these factors taken together bear the possibility of discouraging potential users from seeing EVs as a positive future prospect and thus from interpreting EVs as a valuable alternative to conventional mobility concepts, which seems to be the ultimate psychological prerequisite for heating up the EV market. Several studies attest to the everyday requirements of EVs (Bunce et al., 2014; Vilimek et al., 2012), using a longer-term study design to demonstrate an increase in the acceptance of EVs (Labeye et al., 2013; Neumann et al., 2010). Therefore it seems rather difficult to assess potentials of changing ordinary people's attitudes towards EVs in a short period of time. The German National Platform for Electromobility advocates four key areas for increasing public awareness and improving public opinion (NPE, 2012): (1) communicate advantages and the everyday suitability of e-mobility, (2) emphasize the positive ecological impact of electric driving, (3) reduce operating costs and, finally, (4) improve the charging processes. The latest development in charging technology offers the possibility of charging EVs very quickly (see Table 1), which

* Corresponding author at: University of Bamberg, Department of General Psychology and Methodology, Markusplatz 3, D-96047 Bamberg, Germany.
E-mail address: ccc@experimental-psychology.com (C.-C. Carbon).

http://dx.doi.org/10.1016/j.techfore.2016.02.006
0040-1625/

Table 1
Different charging modalities of EVs, the corresponding charging power in kW and typical approximate charging duration from a nearly empty up to a fully loaded battery (dependent on local electricity infrastructure and charging equipment).

Charging modality	Charging power	Duration
Standard AC charging (e.g. household socket)	3.7 kW	6–8 h
Wallbox AC charging	4.6 kW–7.4 kW	3–6 h
Fast DC charging	Up to 50 kW	0.5–1 h

may now permit the evaluation of proposed improvement caused by fast-charging technologies—one of the four key areas announced by the NPE (2012) to increase public awareness and improving public opinion. It is based on DC (direct current) supply with a high current strength of up to 50 kW, which enables the charging of an EV with a nearly empty battery to a capacity of 80% in less than 30 min—much faster than conventional AC charging technology which needs several hours for the same gain of battery energy (Botsford and Szczepanek, 2009). Additionally, the Technology Acceptance Model (Davis, 1989) as well as its extensions (Venkatesh and Davis, 2000) predict that the perceived usefulness of a new technology is one of the most important factors for technology acceptance (Legris et al., 2003). Therefore, we were interested whether the present 50 kW DC fast-charging stations are able to increase the perceived usefulness of e-mobility and might affect potential users' attitudes towards e-mobility and their assessment on the prospect of EVs.

Since the International Society of Automotive Engineers (SAE) and the European Automobile Manufacturers Association (ACEA) determined the combined charging system (CCS) as a standard for fast-charging facilities, an important impulse was set for the compatibility of EVs with public charging systems. It offers, therefore, an interesting opportunity to reply to typical concerns about the limited range and long-standing recharge cycles of EVs. As the adoption of innovations directly influences the productivity as well as the profit of countries and companies (Mairesse and Mohnen, 2002) it seems important to be able to predict those progressions for the future of e-mobility. With the Repeated Evaluation Technique (RET) introduced by Carbon and Leder (2005) – a method to capture the dynamic effects of innovations – we are able to examine the dynamic effects fast-charging has on the attitudes of potential users. Using the RET we conducted two experiments in which participants either actively experienced the charging technologies or only passively received pure information about these technologies. We predict that experiencing fast-charging will positively impact the perception towards e-mobility.

2. Experiment 1

In the first experiment we were interested in the impact that actively using the new DC-system would have on people's attitudes towards e-mobility and their assessment on the prospect of EVs becoming a major mobility concept in the future.

For a valid ecological design we simulated a typical charging process and designed a specific method that enables us to track changes in user attitude and assessments on e-mobility while interacting with the vehicle. The method we used was inspired by the Repeated Evaluation Technique (RET) by Carbon and Leder (2005) which enables the capturing of dynamic effects concerning innovative aspects of e.g. e-mobility, already employed by a series of experimental (Faerber et al., 2010) as well as psycho-physiological procedures (Carbon et al., 2008). By selectively familiarizing participants with either the conventional, slow-charging AC-system or the advanced, fast-charging DC-system, we were able to compare the different effects these two charging systems have on people's attitudes towards, and assessments on, e-mobility. In order to additionally have the ability to observe changes over time, participants were asked to fulfill a questionnaire before (t1) and after (t2) the charging process. Between these questionnaires, participants were interviewed in the car while the charging was in progress to a) let them experience the fast DC- or slow AC-charging process, b) get information about the spare time activities they would favor during a charging process and c) ask them about usability and safety perception with regard to the charging procedure.

2.1. Method

2.1.1. Participants

Forty-six men and sixteen women (total $n = 62$), ranging in age from 18 to 75 years ($M = 43.6$ years SD $= 14.8$), agreed to participate in our study. All participants were randomly chosen German visitors from the "BMW Welt" (Engl.: "BMW World"—a multi-functional customer experience and exhibition facility of the BMW Group, located in Munich, Germany). After the experiment, participants received a gift coupon valued at € 7.— in compensation to be redeemed at the nearby BMW Welt.

2.1.2. Apparatus and stimuli

The charging station we used in this experiment was from the Asea Brown Boveri (ABB) group laid out for the combined charging system (CCS). The BMW Group provided a BMW ActiveE conversion electric vehicle assembled with a 28 kWh battery and a range of approximately 160 km that was compatible with the CCS standard. To gain optimal experimental control we decided to use a simulation app on a white SONY Xperia Z Tablet that was mounted on the original charging station screen. This app was able to simulate a time-synchronized typical charging procedure for the AC as well as the DC condition. The tablet-PC as well as the implemented app was adjusted to the charging station in such a way that it was hardly distinguishable from the original, unmodified charging station in order to keep the scenario as realistic as possible—in fact, none of the participants noticed the mock-up quality of the employed setting.

2.1.3. Setting and procedure

The field experiment took place in front of the main gate of BMW Welt in Munich, Germany over 2 weeks in summer 2013 (from the end of July until the beginning of August) when a charging station from ABB group equipped with the CCS standard was installed.

Participants were accompanied to the testing site where they first read and signed their written consent. As shown in Fig. 1, participants then filled in the t1 questionnaire. In this questionnaire, participants answered questions concerning their socio-demographic details, attitudes towards EVs, assessment of the future prospects of EVs, innovativeness, environmental attitude and existing experience. All quantitative data were measured on a seven-point rating scale from 1 to 7 ($1 =$ do not agree at all; $7 =$ do absolutely agree). The exact wording of the items we report here is listed under Appendix A.

In the elaboration phase, participants were first introduced to the set-up for charging the electric vehicle. Afterwards they were given additional information about the charging station and the duration of the charging process depending on whether they were in the slow (AC) or in the fast (DC) condition. In the AC condition participants were told it would take up to 6–8 h to fully charge the car, while in the DC condition people were told it would only take approximately 20 min to charge the almost empty battery up to 80% (see Table 1). Subsequently, participants were asked to start the charging procedure without further instruction from the experimenter. Participants connected the plug with the vehicle and started the process on the display. As described before, participants were made to think that the charging was proceeding for real. To make sure the scenario was trustworthy, participants were informed after the experiment about the simulation in a debriefing session and asked if they had noticed the modification at any time or had had doubts about whether this was a real charging procedure. None of the participants said they had noticed at any time that the procedure was only a simulation instead of a real charging process.

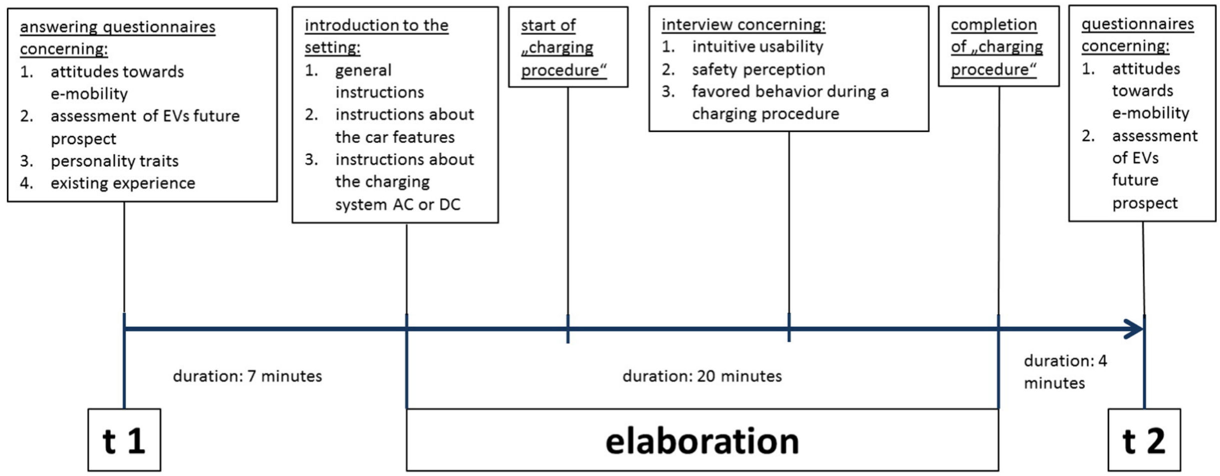

Fig. 1. Procedure and time course for both charging simulations.

The app was basically programmed the same way as the original in the charging station. Depicted were a start/stop button and a bar showing the actual battery status added by the percentage specification. Calculations for the charging progress were based on the battery capacity of the BMW ActiveE and the charging power of the standard AC and fast DC charger respectively (see Table 1). After starting the charging procedure, the participant and the interviewer entered the BMW ActiveE where the interview was completed (Fig. 2). During the interview, information concerning usability, safety and favored behavior during a charging procedure was obtained. Subsequently, the participant and the interviewer left the car in order to terminate the charging and unplug the car.

As a last step, participants completed the t2 questionnaire as part of the method. Again we obtained information concerning attitudes towards EVs and assessment on the future prospect of EVs. Finally, participants were debriefed about the aims of the study.

2.2. Results

In Experiment 1 we focused on whether the advanced, fast-charging DC-system has an impact on people's attitude towards EVs and the way they see the future prospects of EVs compared to the conventional, slow-charging AC-System in separate groups.

To measure the progression over time we calculated the difference between the given data after (t2) and before (t1) the charging procedure took place. For the first analysis we used a one-sample t-test to test each difference value in each condition against 0. In the second analyses we used an independent sample t-test to compare the differences between the slow AC condition and the fast DC condition. As we proposed that the fast DC charging would improve people's attitudes towards EVs, we tested $p < .05$ one sided. Participants' attitudes towards EVs increased in the AC condition [$t(31) = 2.03$, $p = .0255$, $d = .38$] as well as in the DC condition [$t(29) = 2.07$, $p = .0235$, $d = .36$] significantly. This indicates that by merely experiencing e-mobility, the concept of EVs and their charging system especially leads to better rating in terms of their attitudes towards EVs. The difference between the AC and DC condition concerning these judgments was not significant [$t(60) < 1$, n.s.] (see Fig. 3).

Regarding assessment on the future prospect of EVs, only ratings in the DC condition rose significantly [$t(29) = 2.29$, $p = .0175$, $d = .46$] documented via a medium-large effect—we did not obtain any change in the AC condition [$t(31) < 1$, n.s.]. Furthermore, the difference between DC and AC condition regarding the assessment on the future prospect of EVs showed a significant outcome with a medium-large effect [$t(60) = 1.94$, $p = .0285$, $d = .50$] (see Fig. 3).

3. Experiment 2

In Experiment 2 we aimed to investigate the role of experiencing fast-charging, i.e. whether it is necessary to let participants actively experience e-mobility in terms of the charging procedure, or whether the same effects can be attained purely by giving them written information.

Therefore, we used the same design as in Experiment 1, but instead of conducting the charging procedure and taking part in an interview on the information about the BMW ActiveE, the charging technology and questions concerning their favored behavior during a charging procedure were presented in written forms and participants had to fill in their answers – in exactly the same chronological order as in Experiment 1 – with a pen.

3.1. Method

3.1.1. Participants

Fifty-one women and eleven men (total $n = 62$), ranging in age from 17 to 29 years ($M = 20.2$ years; SD = 2.04) participated in this study. All participants were students from the University of Bamberg and were given € 7.—in compensation.

3.1.2. Apparatus and stimuli

Instead of using the real ABB charging station and the BMW ActiveE, we illustrated the new DC fast-charging technology by presenting photographs of the whole setting which we had used in Experiment 1 (e.g. Fig. 2) to get a typical impression of the scenario and the linked technology usually presented in press material. Since there was no app that simulated a time-synchronized typical charging procedure, we used written information about the relationship between time and battery status during a charging procedure adjusted to the AC or DC condition.

3.1.3. Setting and procedure

The experiment took place in the facilities of the University of Bamberg in January 2014.

As mentioned previously, the process of Experiment 2 was exactly the same as in Experiment 1 except that participants did not actively take part in the charging procedure, but were given the identical information and questionnaires in written form. Questions about the usability of the charging station were removed because they were meaningless in the given context.

3.2. Results

In order to test each different value in each condition against null we again used a one-sample t-test; and in order to compare the differences

Fig. 2. Showing a typical test scenario in the study.

in the slow AC condition with the fast DC condition an independent sample t-test was used. Participants' attitudes towards EVs in Experiment 2 did not significantly increase in either the AC condition [$t(31) < 1$, n.s.] or the DC condition [$t(29) < 1$, n.s.] (see Fig. 4). Additionally, the difference between the AC and DC condition showed no significant effect [$t(60) < 1$, n.s.]. No effects in the assessment of the future prospect of EVs could be seen, whether in the AC condition [$t(31) < 1$, n.s.], the DC condition [$t(29) = 1.07$, $p = .293$, n.s.] or in the difference between the AC and DC condition [$t(60) < 1$, n.s.] (see Fig. 4).

4. Conclusions and discussion

Due to the development of fast DC-charging in public, a new opportunity is presented to make EVs seem more attractive. Results in Experiment 1 have shown that people's opinion about the future prospect of EVs increased significantly in the DC condition compared to the AC condition. Interestingly, attitudes towards EVs increased in the AC and in the DC condition. However, none of these effects could be revealed in Experiment 2 where participants were only handed out the same information in written form instead of being allowed to actively experience the different charging technologies. In the following section we will outline possible explanations for our findings.

Although EVs are still a controversial topic of discussion among some researchers (Doring and Aigner, 2011; Mohseni and Stevie, 2010), previous studies have shown that hands-on experience with EVs in everyday driving scenarios is crucial for the acceptance of this new transport technology in general (NPE, 2012; Turrentine et al., 2011; Vilimek and Keinath, 2014) and in order to reduce psychological barriers concerning EV's limited range (Franke et al., 2012b). The experiments reported here give hints for increasing EV acceptance by positively affecting people's perception of e-mobility when experiencing DC fast-charging. In Experiment 1, we obtained an important effect for people's assessment of EVs being the future which only rose when the participants used an active fast-charging procedure taking about 30 min. Attitudes towards EVs were positively affected by the slow AC and fast DC condition in Experiment 1, which might indicate that the AC system will also be regarded as a useful option for recharging by the majority of potential customers but in a different context—e.g. at home, overnight or during work (Robinson et al., 2013). A different explanation is that mere exposure to a product increases the fluency of processing and is known to increase the appreciation for it as documented in the visual (Zajonc, 1968) as well as the haptic domain (Jakesch and Carbon, 2012). Mere exposure can also encourage a consumer to have a more favorable attitude towards a brand (Janiszewski, 1993). Possibly, the assessment of EV's future prospect feels less related to the self, whereas the attitude towards EV is more related to the self, and so mere exposure influenced participants' attitudes but not their possible assessment of EV's future prospect.

Nevertheless, none of these effects could be achieved in Experiment 2 by just handing out the same information, so letting experience

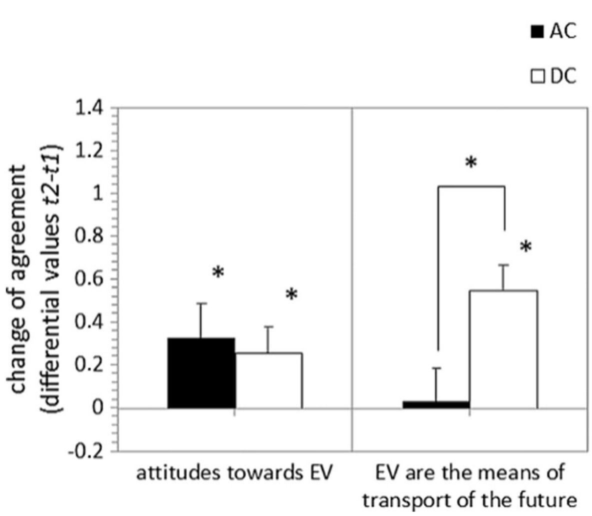

Fig. 3. Change of agreement for slow AC and fast DC charging condition concerning attitudes towards EV and assessment of the future prospect of EVs. $^{*}p < .05$ (one sided).

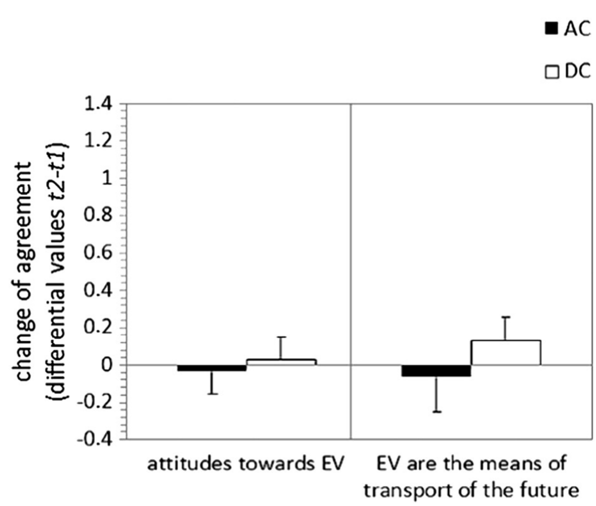

Fig. 4. Change of agreement for slow AC- and fast DC-charging condition regarding attitudes towards EVs and assessment of the future prospect of EVs in the passive elaboration (Experiment 2).

e-mobility quite passively instead of getting familiar with DC fast-charging technology through an active charging procedure. Therefore, another approach is that letting people actively take part in e-mobility issues might generally increase the attitude towards this technology by typical familiarization effects often found in the literature (e.g., via increased fluency, see Albrecht and Carbon, 2014; Reber et al., 1998) when innovative products are to be evaluated (Carbon et al., 2008)—in other words: you need to be familiar with something innovative to be able to appreciate it, and the likelihood of such familiarization seems to be better guaranteed by active than by passive elaboration. Obviously, to qualify the future of e-mobility people must experience it rather than read about it. Really convincing and also fit for the future only seems to be a technology which is charging sufficiently fast—but such an insight could not be documented when people only read about the facts on fast-charging; they mandatorily had to experience it. Like the Aesthetic-Aha! effect revealed by Muth and Carbon (2013), participants may need such an Aha effect when familiarizing with e-mobility charging technologies. When they experienced fast charging not only in theory but in practice when doing so on their own, this might have induced the evaluation that the car is now really ready for a longer trip just after some minutes of charging—this evaluation was effectively supported by showing a quickly advancing progress bar on the screen. Therefore, we assume that participants perceived an increase in the usefulness of e-mobility initiated by the experience of the fast-charging system, which is in line with former findings regarding the Technology Acceptance Model (e.g., Legris et al., 2003; Venkatesh and Davis, 2000). This idea was reflected by typical comments of participants taking part in the active DC fast-charging condition of Experiment 1 by pointing out that they "didn't expect the charging to be so fast" or "always thought to have to wait for six hours before continuing the journey." These findings fit to previous research about e-mobility where it has been shown that actively exploring the range of EVs was linked to a more successful adaptation (Franke et al., 2012a, 2012b). However, we explicitly do not conclude that the passive engagement with EVs has no influence on the favorability of EVs at all, since we used a different sampling population and conducted Experiment 2 in a different setting. Thus, another possible reason might be that undergraduates (in Experiment 2) are simply generally less inclined to care about EVs than adults who were self-selected into visiting the BMW exhibition facility. Additionally, we cannot judge whether only interacting with the car instead of charging it would have greater or lesser effects on people's acceptance of e-mobility. Thus, we can only assume that the likelihood for raising attitudes towards EVs increases when people actively take part in the way e-mobility works.

In facing the challenges for an ecologically valid transportation system, it is important to improve the perception towards EVs with regard to public authorities and especially public opinion as a whole (Spickermann et al., 2014). Therefore, fast charging opportunities seem to be another step in the right direction of fulfilling potential consumer expectations.

Additionally these experiments demonstrated possible implications of how e-mobility could be brought closer to a wide range of people. Merely by letting people engage with the concept of e-mobility and giving them the chance to actively explore the facilities of EVs, especially the method of charging, their attitudes towards EVs improved significantly. Although other studies have shown pre-post effects before, it was mostly during a long trial period (Cocron et al., 2011; Jensen et al., 2013). The possible insights derived from our studies can now help to transfer this adaptation process to the active exploration of fast-charging systems leading to an increase of the assessment of the future prospect of EVs. Taken together, e-mobility may become more attractive when potential customers have the chance to actively take part in the way e-mobility works, bearing in mind that fast DC charging is capable of improving assessments of the future prospect of EVs.

Appendix A

Table 2
Wording of the items used in Experiment 1 and Experiment 2 concerning the variable attitudes (Cronbach's $a = .86$) and assessment of the future prospect of EV's.

Attitudes
In my opinion, electric vehicles would make a good impression on other people. [German: Meines Erachtens machen Elektrofahrzeuge bei anderen einen guten Eindruck.]
Electric vehicles please me. [German: Elektrofahrzeuge gefallen mir.]
I would like to use electric vehicles. [German: Ich wtirde Elektrofahrzeuge geme fahren.]
Electric vehicles would give me pleasure. [German: Elektrofahrzeuge wiirden mir Freude machen.]
Assessment of the future prospect of EVs
Electric vehicles are the means of transportation of the future. [German: Elektrofahrzeuge sind das Verkehrsmittel der Zukunft.]

Acknowledgments

The present studies were funded by the German Federal Ministry of Economy, Transportation, Research and Environment. In appreciation of the coordination of the Project "DC-Ladestation am Olympiapark," including the study at the BMW Welt, we thank the head of the project Gilbert Lenski from BMW Group. We would especially like to thank Julia Messerschmidt from the Spiegel Institute and Géza Harsányi from Forschungsgruppe EPÆG (Bamberg), who put a lot of effort into organizing and planning the research at the BMW Welt. Additionally we thank our student researchers Simone Deibel, Catharina Eichert, Dora Faludi, and Anne Rücker, also from Forschungsgruppe EPÆG (Bamberg) for their assistance in conducting Experiment 1 in Munich. Last but not the least, we wish to thank Fred Young Phillips and two anonymous reviewers for providing very valuable comments and ongoing constructive criticism for an earlier version and the revisions of this article.

References

Albrecht, S., Carbon, C.C., 2014. The fluency amplification model: fluent stimuli show more intense but not evidently more positive evaluations. Acta Psychol. 148, 195–203. http://dx.doi.org/10.1016/j.actpsy.2014.02.002.

Bayram, I.S., Michailidis, G., Devetsikiotis, M., 2013. Electric Power Resource Provisioning for Large Scale Public EV Charging Facilities. IEEE, New York.

Botsford, C., Szczepanek, A., 2009. Fast charging vs. slow charging: pros and cons for the new age of electric vehicles. Paper presented at the EVS24 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium, Stavanger.

Bunce, L., Harris, M., Burgess, M., 2014. Charge up then charge out? Drivers' perceptions and experiences of electric vehicles in the UK. Transp. Res. A Policy Pract. 59 (0), 278–287. http://dx.doi.org/10.1016/j.tra.2013.12.001.

Carbon, C.C., Leder, H., 2005. The repeated evaluation technique (RET). A method to capture dynamic effects of innovativeness and attractiveness. Appl. Cogn. Psychol. 19 (5), 587–601. http://dx.doi.org/10.1002/acp.1098.

Carbon, C.C., Michael, L., Leder, H., 2008. Design evaluation by combination of repeated evaluation technique and measurement of electrodermal activity. Res. Eng. Des. 19 (2–3), 143–149. http://dx.doi.org/10.1007/s00163-008-0045-2.

Cocron, P., Bühler, F., Neumann, I., Franke, T., Krems, J.F., Schwalm, M., Keinath, A., 2011. Methods of evaluating electric vehicles from a user's perspective — the MINI E field trial in Berlin. IET Intell. Transp. Syst. 5 (2), 127–133. http://dx.doi.org/10.1049/iet-its.2010.0126.

Davis, F.D., 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q. 13 (3), 319–340. http://dx.doi.org/10.2307/249008.

Doring, T., Aigner, B., 2011. E-mobility: realistic vision or hype — an economic analysis. Przegl. Elektrotechniczny 87 (3), 37–40.

Faerber, S.J., Leder, H., Gerger, G., Carbon, C.C., 2010. Priming semantic concepts affects the dynamics of aesthetic appreciation. Acta Psychol. 135 (2), 191–200. http://dx.doi.org/10.1016/j.actpsy.2010.06.006.

Franke, T., Cocron, P., Bühler, F., Neumann, I., Krems, J.F., 2012a. Adapting to the range of an electric vehicle—the relation of experience to subjectively available mobility resources. Paper presented at the Proceedings of the European conference on human centred design for intelligent transport systems, Valencia, Spain.

Franke, T., Neumann, I., Buhler, F., Cocron, P., Krems, J.F., 2012b. Experiencing range in an electric vehicle: understanding psychological barriers. Appl. Psycholo. Int. Rev. Psychol. Appl.-Rev. Int. 61 (3), 368–391. http://dx.doi.org/10.1111/j.1464-0597.2011.00474.x.

Holdway, A.R., Williams, A.R., Inderwildi, O.R., King, D.A., 2010. Indirect emissions from electric vehicles: emissions from electricity generation. Energy Environ. Sci. 3 (12), 1825–1832. http://dx.doi.org/10.1039/c0ee00031k.
Jakesch, M., Carbon, C.C., 2012. The mere exposure effect in the domain of haptics. PLoS One 7 (2). http://dx.doi.org/10.1371/journal.pone.0031215.
Janiszewski, C., 1993. Preattentive mere exposure effects. J. Consum. Res. 20 (3), 376–392. http://dx.doi.org/10.1086/209356.
Jensen, A.F., Cherchi, E., Mabit, S.L., 2013. On the stability of preferences and attitudes before and after experiencing an electric vehicle. Transp. Res. D Transp. Environ. 25, 24–32. http://dx.doi.org/10.1016/j.trd.2013.07.006.
Jin, C.R., Tang, J., Ghosh, P., 2013. Optimizing electric vehicle charging: a customer's perspective. IEEE Trans. Veh. Technol. 62 (7), 2919–2927. http://dx.doi.org/10.1109/TVT.2013.2251023.
Kampker, A., Burggraf, P., Nee, C., 2012. Costs, Quality and Scalability: Impact on the Value Chain of Electric Engine Production. IEEE, New York.
Kraftfahrt-Bundesamt, 2015. Bestand an Personenkraftwagen am 1. Januar 2015 nach ausgewählten Kraftstoffarten. http://www.kba.de/DE/Statistik/Fahrzeuge/Bestand/Umwelt/2014_b_umwelt_dusl_absolut.html.
Labeye, E., Adrian, J., Hugot, M., Regan, M.A., Brusque, C., 2013. Daily use of an electric vehicle: behavioural changes and potential for ITS support. IET Intell. Transp. Syst. 7 (2), 210–214. http://dx.doi.org/10.1049/iet-its.2012.0155.
Legris, P., Ingham, J., Collerette, P., 2003. Why do people use information technology? A critical review of the technology acceptance model. Inf. Manag. 40 (3), 191–204. http://dx.doi.org/10.1016/s0378-7206(01)00143-4.
Mairesse, J., Mohnen, P., 2002. Accounting for innovation and measuring innovativeness: an illustrative framework and an application. Am. Econ. Rev. 92 (2), 226–230. http://dx.doi.org/10.1257/000282802320189302.
Mohseni, P., Stevie, R.G., 2010. Electric Vehicles: Holy Grail or Fool's Gold. Paper presented at the IEEE Power and Energy Society General Meeting 2010.
Muth, C., Carbon, C.C., 2013. The aesthetic aha: On the pleasure of having insights into Gestalt. Acta Psychol. 144 (1), 25–30. http://dx.doi.org/10.1016/j.actpsy.2013.05.001.
Nationale-Plattform-Elektromobilität(NPE), 2012. Fortschrittsbericht der Nationalen Plattform Elektromobilität (Dritter Bericht). http://www.bmub.bund.de/fileadmin/bmu-import/files/pdfs/allgemein/application/pdf/bericht_emob_3_bf.pdf.
Neumann, I., Cocron, P., Krems, J.F., 2010. Electric vehicles as a solution for green driving in the future? A field study examing the user acceptance of electric vehicles. In: Krems, J.F., Petzold, T., Henning, M. (Eds.), Proceedings of the European Conference on Human Interface Design for ITS. Germany, Berlin.
Reber, R., Winkielman, P., Schwarz, N., 1998. Effects of perceptual fluency on affective judgments. Psychol. Sci. 9 (1), 45–48. http://dx.doi.org/10.1111/1467-9280.00008.
Robinson, A.P., Blythe, P.T., Bell, M.C., Hubner, Y., Hill, G.A., 2013. Analysis of electric vehicle driver recharging demand profiles and subsequent impacts on the carbon content of electric vehicle trips. Energy Policy 61, 337–348. http://dx.doi.org/10.1016/j.enpol.2013.05.074.
Schwedes, O., Kettner, S., Tiedtke, B., 2013. E-mobility in Germany: white hope for a sustainable development or fig leaf for particular interests? Environ. Sci. Pol. 30, 72–80. http://dx.doi.org/10.1016/j.envsci.2012.10.012.
Spickermann, A., Grienitz, V., von der Gracht, H.A., 2014. Heading towards a multimodal city of the future? Multi-stakeholder scenarios for urban mobility. Technol. Forecast. Soc. Chang. 89, 201–221. http://dx.doi.org/10.1016/j.techfore.2013.08.036.
Steinhilber, S., Wells, P., Thankappan, S., 2013. Socio-technical inertia: understanding the barriers to electric vehicles. Energy Policy 60, 531–539. http://dx.doi.org/10.1016/j.enpol.2013.04.076.
Turrentine, T., Garas, D., Lentz, A., Woodjack, J., 2011. The UC Davis MINI E Consumer Study. Insitute of Transportation Studies University of California, Davis, pp. 1–78.
Venkatesh, V., Davis, F.D., 2000. A theoretical extension of the technology acceptance model: four longitudinal field studies. Manag. Sci. 46 (2), 186–204. http://dx.doi.org/10.1287/mnsc.46.2.186.11926.
Vilimek, R., Keinath, A., 2014. User-centred design and evaluation as a prerequisite for the success of disruptive innovations: An electric vehicle case study. In: Regan, M., Horberry, T., Stevens, A. (Eds.), Driver acceptance of new technology: theory, measurement and optimisation. Ashgate, Farnham, pp. 169–186.
Vilimek, R., Keinath, A., Schwalm, M., 2012. The MINI E field study — similarities and differences in international everyday EV driving. In: Stanton, N.A. (Ed.), Advances in human aspects of road and rail transportation, pp. 363–372.
Zajonc, R.B., 1968. Attitudinal effects of mere exposure. J. Pers. Soc. Psychol. 9 (2), 1–27. http://dx.doi.org/10.1037/h0025848.

Fabian Gebauer is a PhD student at the Department of General Psychology and Methodology at the University of Bamberg, Germany. In his research he combines methodology and innovativeness research from a psychological perspective to study the role of different charging opportunities in the field of e-mobility. He is a graduateof Master of Science at the University of Bamberg in Psychology.

Claus-Christian Carbon is a professor of cognitive psychology and methodology. He has worked at the University of Vienna, the University of Warsaw, Delft University of Technology, and the University of Bamberg, where he currently holds a full professorship leading the Department of General Psychology and Methodology and the "Forschungsgruppe EPÆG"—a research group devoted to enhancing knowledge, methodology and enthusiasm in the fields of cognitive ergonomics, psychological esthetics and design evaluation. He is an editor and member of the editorial board of several international scientific journals. In 2013 he founded the Graduate School of Affective and Cognitive Sciences (BaGrACS) in Bamberg, Germany.

Roman Vilimek works in the BMW Group Concept Quality and Usability department. He is responsible for user research and scientific coordination in the international electromobility pilot projects conducted by the BMW Group with public, private and academic research partners. He graduated with a degree in psychology from University of Regensburg and received his doctorate with highest distinctions for research on innovative in-vehicle interaction concepts. Before his current engagement he worked for several years on various human–machine interaction topics like the user-centered design of advanced interaction technologies, multimodal in-vehicle systems, health care systems and intranet applications at Siemens' Corporate Technology.

Andreas Keinath graduated with a degree in psychology from University of Regensburg in 1997. He received his doctorate from University of Technology in Chemnitz in 2003. After his PhD he started working at BMW Group Research and Technology and worked intensively on driver distraction and HMI design und evaluation. Since 2009 he is Head of Concept Quality and Usability of the BMW Group. In this position he was responsible for the coordination of the scientific research of the international MINI E and BMW Active E projects. His research interests include field trials of innovative systems, distraction research and HMI evaluation.